VOL. 2. NO. 3.

THE

Sidereal Messenger.

Conducted by Wm. W. PAYNE,

Director of Carleton College Observatory.

MAY, 1883.

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To impress upon the mind the reality of the perfection of the works of the omnipotent, the living GOD.—Professor JAMES C. WATSON.

THE MESSENGER will be published monthly, except for July and September. Subscription price per year (ten numbers), $2.00.
All communications should be addressed to the Editor,
Northfield, Minnesota.

NORTHFIELD, MINN.
CARLETON COLLEGE OBSERVATORY.
1883.

Entered at the Postoffice at Northfield, Minn., and admitted for transmission through the mails at second-class rates.

The Sidereal Messenger.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 2. NO. 3. MAY, 1883. WHOLE NO. 13.

TWO PROBLEMS IN SIDEREAL ASTRONOMY.

JACOB ENNIS.

In sidereal astronomy there are two great departments of work to be done, which result from the fact that there is a large intergravitating force between all the stars of our sidereal system. Before the distances between our sun and any of the fixed stars became known, it had been supposed, even from the days of Newton, that there could be no sensible force of gravity between the fixed stars, or between our sun and them. So settled was this ancient belief, that after the distances of some of the fixed stars had been ascertained, nearly thirty years elapsed before any one thought of testing it by calculation. Then it was found to be considerable between any two stars, but wonderfully large between all the stars of our sidereal system when combined together. Then there was astonishment that this large interstellar gravitating force had been so long in active exercise without its being known or even suspected.

The most impressive method to illustrate this intergravitating force, is to demonstrate the velocity at right angles to the line of vision, which any star must possess, in order to prevent its falling into our sun by the sun's gravitation. There are two handy ways to make this demonstration. The first is to regard the star, whose distance is known, as a planet of our sun, and then apply Kepler's third law:—as the cube of the distance of *Neptune* is to the cube of the distance of the fixed star, so is the square of the time of *Neptune*, to the square of the time of the star.

The second way is by calculating the fall of a body toward our sun, from infinite space to the orbit of any planet, or to the orbit of a fixed star regarded as a planet. The velocity of this fall, our sun's gravity alone being considered, is to the velocity of a planet in any orbit as the square root of two is to one, or $\sqrt{2}: 1$. By calculating the velocity of this fall, therefore we easily find what must be the velocity of the fixed star at right angles to the direction of our sun, in order to gain centrifugal force enough to balance the centripetal, or the gravitating, force. The formula I use to calculate the velocity of this fall toward our sun from infinite space, is the following: $V = \sqrt{(2\,g\,v)}$. Here v represents the distance from the sun to the orbit of the planet; g represents the velocity per second acquired by a fall toward the sun during one second at the distance from that orbit. This velocity may be found by comparing the mass and radius of the earth with the mass of the sun and its radius as if extended to the orbit in question.

By both these processes it is interesting to go from star to star whose distances have become known, and compute the flight they must have, to acquire a centrifugal force to avoid plunging into our sun. *Alpha Centauri* must move 145 miles per hour. This results from regarding our sun's gravity alone. The light of this star is 2.32 times greater than our sun's; and if his mass is in the same proportion, then our sun must move 222 miles per hour, at right angles to to the direction of that star, to keep from falling in to its flames. Here only the gravity of *Alpha Centauri* is considered. The light of *Sirius* is allowed by all astronomers to be 60 times greater than our sun's. By the experiments of Clark of Boston, it is more than 200 times greater. But if his mass be only 60 times greater, then by considering his gravity alone, our sun must fly 580 miles per hour, at right angles to Sirius, to gain a centrifugal force to equal the gravitation of that star.

These calculations are made by counting alone the gravity of a single star. What then must be the combined gravitation of the many millions of stars of our sidereal system, upon any one of its stars! If we multiply any of the above

members about Sirius and *Alpha Centauri* by 100,000, what enormous products do we obtain. But our sidereal system is supposed to contain 30 or 40 millions of luminous stars. The wisest astronomers like Arago, Humboldt and others, suppose it may have an equal, or a still larger, number of non-luminous stars, whose fires like those of our planets and some known fixed stars, have burned out. If we regard these 30 or 40 millions of luminous stars of our system, and an equal or greater number of unluminous ones, how great must be their combined intergravitation. This is *one way* to account for the large proper motions of the so-called fixed stars,—at least 5,000 of which have been found to possess proper motions, more or less.

But what must be the systematic movements of the stars of our sidereal system? This question must be answered in precisely the same manner as the same question about the members of our solar system. The stars must all, without exception, revolve around the common centre of gravity of our sidereal system, this is absolutely unavoidable. Whatever theoretical differences we may have about other points, there can be none about this. Our sidereal system is a separate and definite cluster of stars. It stands alone in the heavens. The force of gravity is in mutual operation among all its members. Newton declared: "If all matter were evenly diffused through a finite space, and endowed with innate gravity, it would fall down in the middle of the space, and form one great spherical mass; but if all matter were diffused through infinite space, some of it would collect into one mass, and some into another, so as to form an infinite nunber of great masses." The application of this to our sidereal system is unmistakable. That system is "diffused through a finite space" only, and "it is endowed with innate gravity." Therefore it must all fall down in the middle of that space and form one great spherical mass, unless hindered from so doing by revolution and centrifugal force. This centrifugal force acquired by revolving around its common centre of gravity, is what saves our solar systen from a destructive rush to its center. Among the fixed stars, this is what preserves the binary and ter.

nary systems. There cannot be the least doubt, but that this same revolution around its center of gravity, preserves our sidereal system.

The Galaxy or the Milky Way is well known to be a great ring of stars, like the rings of *Saturn*, or the ring of the asteroids, or the other nebulous rings seen in the heavens. It is supposed by some astronomers to contain nineteen-twentieths of the stars of our sidereal system. Whether this proportion be exact or not, most certainly it contains the vast majority. All the other stars are about equally distributed on both its sides. Therefore the centre of gravity of our sidereal system, must lie in the plane of the median line of that great ring. And as the stars are about equally numerous in all extended parts of that ring, that center of gravity must lie in the center of the plane. Therefore the vast ring of the Milky Way must revolve around that center like a great wheel! These conclusions are inevitable, and they are full of meaning.

We come now to one of the two great departments of work to be done in sidereal astronomy which were referred to in the first sentence of this article. First, to answer this question:—Which way does the Milky Way revolve? We stand and look at the Galaxy in a clear moonless sky, and knowing it must revolve around its center, we ask ourselves in which of the two directions does the great wheel turn? Individually and alone, this question is clothed with general and absorbing interest, both to the simple and to the sage. But to the astronomer it comes with a deeper meaning. He sees most clearly that this is a first and most decisive step toward learning the revolutions of all other stars, and towards making us as familliar with the mechanism and the movements of our sidereal system, as we now are with that of our solar system.

How shall we learn which way the Milky Way revolves? Only by making a thorough investigation of the proper motions of its stars. They will be found to have a general drift one way or the other. Those of the sixth, seventh and eight magnitudes will most readily give us the desired information. Its ninth magnitude stars are so nu-

merous, and their regular motions are so slow, as to be unpropitious in primary investigations. While many of those of its larger magnitudes, may not be really in the Galaxy, although appearing there, but far on this side of it. Therefore there should be at once constructed a great map or atlas of the Galaxy, including all its stars from the first to the eight magnitudes. Their positions should be ascertained by new observations; and all the old observations should be collected and printed together under the head of each star in a separate volume Here is the first great work to be done, and it promises the very highest astronomical results. Most certainly it will not be work thrown away.

The second great work to be done in this connection, and referred to in our first sentence, is to ascertain the *direction* and the *distance* from ourselves, of the center of our sidereal system. From the undeniable fact of the intergravitation of the stars, we are sure that its center must lie in the plane of the median line of the Galaxy, and in the center of that plane. But for this, which way are we to look? And how far is it off? These two questions it is proposed to answer satisfactorily in a similar article next month.

Before closing, another idea should be explained. It is that the great volocities of the fixed stars, some of them 2,000 or 3,000 miles per minute, do not require so great a centripital force to retain them in their orbits around the center of our sidereal system, as is required to retain our Earth or Neptune in their orbits around the sun. This results from their vast distances from the sidereal center, and from the fact that the centrifugal force decreases, not inversely as the squares of the distances from the center, like gravity, but inversely as the cubes of the distances. For instance, a mass which would be attracted by gravity toward the sun with a weight of 9,020 pounds at our earth's orbit, would be atracted with a weight of only ten pounds at the orbit of Neptune. The difference is as great as 902 is to one. But the velocities of the two planets, in miles per hour, are 68,000 and 12,500. The difference is nearly as five is to one; comparatively small. Why this comparat tively small difference in velocities, and this much greater

difference in solar attraction? Because at the distance of Neptune the centrifugal force is so small that the planet must move more rapidly in proportion, in order to make up for the deficiency in centrifugal force. The longer the radius, the more nearly does the circumference approach a straight line,—motion in which has no centrifugal force. The fixed stars whose rapid proper motions we know, are removed far away from the center of our sidereal system. Any part of their orbits is nearly a straight line. Therefore their centrifugal force is inconceivably weak, therefore to make up its required strength to equal gravity or the centripital force, they must move with the astonishing velocities we behold. But this 3,000 miles per minute may be an exaggeration.

A page or two back I pointed out one method of realizing the necessity for the great velocities of the fixed stars. Here we behold another. The one is the large combined gravitation of all the stars of our sidereal system toward its center. The other is that in the stars far removed from that center, great velocity is necessary in order to acquire even a small centrifugal force. By the latter alone we will hereafter be able to learn the mass of our sidereal system, of its luminous and its non-luminous stars, the same as in all other systems, solar, planetary and binary.

FOREIGN NOTICES OF AMERICAN ASTRONOMY.

RECENT LITERATURE IN "COPERNICUS."

Resultados del Observatorio Nacional Argentino en Cordoba, B. A. Gould. Vol. II., Observaciones del Ano 1872 (Buenos Aires 1882, LXXVIII, and 296 pp. 4to). The greater part of this splendid volume is taken up by the first installment of the zone-observations which were commenced at Cordoba on September 9, 1872, and closed on Aug. 9, 1875, during which time about 105,000 single observations were made. Of these the present volume contains about 13,000. The zones comprise the part of the heavens between 23° and 80° south declination, and as a security against constant er-

rors the plan included the formation of a more accurate catalogue, containing a number of stars from each zone observed three or four times each with all possible care. The meridian circle was constructed by Repsold; it has a telescope of 122 millimeters and a circle of 716 millimeters diameter, graduated to 4′. All the constants of the instruments have been investigated and the results are all given in the introduction. The right ascensions of all the stars observed at Cordoba depend upon those of the U. S. Coast Survey Catalogue of Fundamental Stars (2nd Ed. 1866) with a few slight modifications, the declinations are deduced from nadir observations, the latitude being assumed equal to $-31° 25' 15''.0$. The zones were 2° in width as far as 47° decl., thence increasing gradually with the declination; they were generally one hundred minutes long. The transits were always observed by Dr. Gould, generally over three wires, and were registered on a chronograph, while an assistant read off one microscope, which was compared with the other three at the beginning and end of the zone. 410 Catalogue and Time Stars were observed in 1872 and the separate and mean results for 1875·0 are given. To this epoch the zone stars are also reduced, and as there is an index to the Zones observed in 1872 at the end of the volume it is very simple to find any star required.

Celestial Charts made at the Litchfield Observatory of Hamilton College, Clinton, N. Y. By C. H. F. Peters. Charts Nos. 1–20. Astronomers will greet this first installment of Professor Peters' long expected star maps with much pleasure. Already in August 1873 Professor Peters exhibited some of his maps and explained their construction at the meeting of the Astronomische Gesellschaft in Hamburg. They are the results of many years' zone observations of stars down to the 12th or 13th magnitude in search of minor planets. The zones were observed in about the same way as the Harvard Zones, and the charts constructed from them were each compared with the heavens on three evenings. The epoch of the charts is 1860 and as none of the charts comprise regions further than 30° from the equator, the same uniform projection could be employed throughout

the scale adopted being 60 millimeters to a degree (about the same as Chacornac's). A star's co-ordinates may be got by the charts with an uncertainty of only 0′.2 resp. 3^s. Each chart covers 20^m in R.A. and 5° in Decl. and is intended to give as complete a picture of the sky as a power of 80 on the 13-inch refractor offers. In the margin of each map are given the scale of magnitudes, references to places where minor planets were discovered by Prof. Peters, the date of the last revision and the precession with opposite sign for the middle of the map. As our readers are already aware (see Vol. I, p. 51) the charts contain a large number of nebulæ, many of them being among the faintest of those found by d'Arrest, Marth and others. The charts are photolithographed and are extremely well looking.

WORK IN FOREIGN OBSERVATORIES.

ABSTRACT FROM "MONTHLY NOTICES" OF THE ROYAL ASTRONOMICAL SOCIETY.

Royal Observatory, Greenwich. The general meridian work at the Royal Observatory during the past year, has given special attention to the observation of the *Moon*, *Sun*, planets, and fundamental stars when they have passed the meridian before 15^h. The larger minor planets have also been observed, about the time of opposition when practicable. The working catalogue of 2,600 stars, including all down to the fifth magnitude, is now nearly cleared off, and a new working catalogue, including all stars down to the sixth magnitude contained in Dr. Heis' *Atlas Coelestis*, which had not been previously observed at Greenwich with the transit circle. Comet *a* 1882 (Wells) has been observed twelve times on the meridian *sub polo*, and comet *b* 1882 (the Great Comet) three times.

The mean error of the *Moon's* tabular R. A. from observations with the transit circle in 1882 is + $0.^s82$.

Two new determinations of the flexure of the transit circle were made Jan. 2, and Dec. 30, 1882, the resulting values being respectively + 0.″03, and − 0.07.

The range of the reflection observations of stars which hitherto was limited to an arc within 40° of the zenith, has been extended to 71° on each side of the zenith. The importance of this extended range of reflection observations is shown from an examination of the mean discordances of (R—D), which for last year steadily increase from the zenith to 70°, at which the discordance between direct and reflex observations amounts to 1."6. Notwithstanding this change in the mounting of the collimators their stability, from day to day, has not been sensibly affected.

With the altazimuth the *Moon* has been observed, at every practicable opportunity to the end of the lunation on July 9, 1882. Since this date, the observations have been restricted to the first and last quarters of each lunation, as it has been shown by a comparison of a number of observations made with the transit circle and altazimuth that the intermediate semi-lunation, before and after full *Moon*, is well represented for all practical purposes by the daily observations made on the meridian. Advantage has been taken of this arrangement to devote greater attention to the observation of comets, and other miscellaneous phenomena with the equatorials. In order to adapt the altazimuth to the observation of comets, a new system of wires, having central cross-wires thicker than the others, was inserted at the beginning of the present year.

Comet *a* 1882 (Wells) was observed on five days, comet *b* 1882, (the Great Comet), on eight days, and comet *c* 1882, (Barnard), on one day. The resulting apparent R. A. and N. P. D. together with the mean places of the comparison stars are published in the *Monthly Notices* for November. Micrometric measures of the positions of six of the satellites of *Saturn*, *Enceladus*, *Tethys*, *Dione*, *Rhea*, *Titan*, and *Iapetus* have also been made on several evenings.

Twelve occultations of stars have been observed in 1882, and eighteen phenomena of *Jupiter's* satellites.

The solar eclipse of May 16, was favorably observed, and four series of differences of R. A. and N. P. D. of the cusps and limbs were obtained. The plan of observing was so arranged as to give corrections to the tabular R. A. and

N. P. D. of the *Moon*, and to the adopted semi-diameters of the *Sun* and *Moon*. During the eclipse, which at its greatest phase only covered 0.186 of the *Sun's* disc, eighteen differences of R. A. of cusps and ten differences of N. P. D. of limbs, and nine differences of N. P. D. of cusps, were observed. The times of the beginning and ending of the eclipse was also recorded by several observers.

The spectroscopic observations have been made as usual with the "half-prism" spectroscope. The routine observations have been less numerous than usual, partly owing to the cloudy weather of the latter half of the year, and partly to the pressure on the photographic department from the increase in the number and size of the Sun-spots as the period of maximum solar activity is approached. The spectra of various Sun-spots have been examined on ten days; the great one of November last being especially remarkable for the instances of reversal of lines which it displayed. The examination of chromosphere and prominences has been made on twenty-two days, and numerous prominences were seen on each occasion.

The displacement of the F or *b* lines has been measured in the spectra of thirty-one stars. This work has suffered some interruption during the period of observation of comets *a* and *b*, the former of which was examined with the spectroscope on eight occasions and the latter on three.

All spectroscopic observations have been completely reduced to the end of 1882.

Photographs of the *Sun* have been obtained with the Photoheliograph on 201 days during the year; whilst in 1881 they were taken in 173 days. The increased number of photographs, and still more the increase in the number and size of the Sun-spots, have rendered the work of their measurement and reduction much more severe than in previous years. The calculations are limited to tenths of a degree instead of to minutes as formerly. The photographs have been measured to the end of 1882 and completely reduced to October 8, 1882.

The printing of the Greenwich observations for 1881 is finished, the whole of the volume being in type in February last.

CENTRAL PARTS OF THE NEBULA OF ORION.

FROM MONOGRAPH BY PROF. E. S. HOLDEN.

It may be well to summarize the foregoing work, in order to review, briefly, the ground over which we have gone and the conclusions which are to be gained. The *object* of the work was twofold: First, to make such a detailed study and description of the central and brighter portions of nebula, that a repetition of the work would be easy and short, and so that the question of any future change in the parts considered can be settled definitely and beyond a doubt and without any great labor. The form in which the observations are classified in Part II seems to me to satisfy this condition. The accuracy of the micrometer measures is sufficient for the purpose, and greater than I anticipated; for example, the $\Delta\delta$ of the brightest part of F is $-102''.0 \pm 0''.3$ (5 nights); of the brightest part of G is $-65''.3 \pm 0''.8$ (6 nights); the position-angle of the *frons* is $50°.3 \pm 0°.5$ (4 nights), and so on. These are surfaces and not points it will be remembered. It will be noted that the first object of my work is precisely that proposed to himself by LE GENTIL in 1758. The second object was to completely and thoroughly discuss the large mass of material already on hand derived from the observations of 224 years (1656-1880). All available drawings were examined, and thirty-eight are here engraved (nearly all on the same scale), and abstracts have been made of all available observations and are here given. Several unpublished series and drawings have been printed for the first time, notably those of LASSELL, SCHMIDT, and LANGLEY. By this examination the epoch of the first trustworthy observations has been carried back from 1824 to 1758. LE GENTIL's figure of the central part yields evidence comparable in value with the first figure of Sir JOHN HERSCHEL.

I conclude that there have been—

(1) possible changes of brightness in the masses of J and B;

(2) changes in the brightness of A;

(3) changes in the brightness of E;

(4) changes in the brightness of D;

(5) undoubted change in the brightnes of SCHROETER'S second bridge;

(6) undoubted changes of brightness in SCHROETER'S bridge and in the appearance of g_0, its nucleus;

(7) a possible change in the position of the south edge of σ since 1837;

(8) a probable change in the brightness of τ'';

(9) a probable change in the brightness of ξ;

(10) a certain change in the development of the mass h near D.

There is no evidence whatever for any change of form other than that which may be due to such changes of brightness; as in the cases of A, D, h, etc. I do not find any change of the *Messierian* branch near 793.

The connection of the stars of the trapezium with the nebula appears to me to be settled by the conclusions of my paper reducing Professor HALL'S observations of these stars, and by various former observations such as the important one by Dr. HUGGINS of those portions of the spectra of α, β, γ, δ, *trapezii*, near the places of the nebula spectral lines 1, 2, 3, and others.

The change in the brightness of D, h, and other masses, is shown by the Washington Observations taken alone. These also show the feasibility of making tolerably accurate photometric observations of the relative brightness of two nebulous masses. Certain of the masses have varied in brightness during the period of observations. A new nebulous patch (h) has been seen from the time of its origin, when it was stellar in appearance and faint, until now, when it is bright and of measurable dimensions.

It appears to me, then, to have been shown that the figures of the nebula of *Orion* has remained the same from 1758 to now (if we except a change in the shape of its apex (E) about 1770, which appears quite possible); but that in the brightness of its parts undoubted variations have taken place, and that such changes are even now going on.

I have not hesitated to give the conclusions to which I

have been led in the course of this work, although I am aware that all of these may not be accepted on a first reading.

With regard to any subject of this kind, every competent judge has a body of opinion derived partly from his own experience and partly from judgments formed from time to time by examinations of the work of others. In general, this body of opinion leans to the view that the phenomena presented by the celestial bodies, are, for long periods of time, quite constant. For example, accounts of supposed changes in the conformation of the lunar craters are received and rightly received with a measure of grave doubt, and yet no one is disposed to deny that real changes are now taking place from moment to moment, just as they have in the past; but each particular recorded evidence of change is regarded with doubt, and a full measure of proof, depending on sufficient observation, is justly demanded. A competent observer is, however, still bound to put his observations on record.

It appears to me that I have less reason to hesitate in recording my own judgments upon the phenomena here described, as the observations themselves are given in full detail, and the materials for an adequate judgment are spread out for inspection.

At least, I can be sure that all the existing evidence is impartially presented in such a way as to be readily added to in the future, and I cannot myself doubt but that the principal conclusions here set down will be confirmed by others.

MOTIONS OF STARS IN LINE OF SIGHT.

The following results are gathered from two valuable papers recently communicated to the "MESSENGER" by the Astronomer Royal of England, which were entitled "Spectroscopic results for the motions of stars in miles in the line of sight obtained at the Royal observatory, Greenwich, in the years 1881 and 1882."

TABLE.

(Recession denoted by +; Approach by —)

Names of Stars.	Number of obs.	Earth's motion in M. per sec. 1881.	Concluded motion of Star. Average of Measures in M. per sec.	Concluded motion of Star. Average of Estimates.
α Andromedae .	3	Dec. 3, + 14.7	— 53.6	— 43.2
β Cassiopeia....	3	" 7, + 8.1	— 35.8	— 32.4
γ Pegasi	3	" 3, + 16.7	— 38.5	— 35.3
δ Andromedae..	3	Nov. 22, + 11.2	— 26.3	— 31.6
β Ceti..........	2	" 19, + 14.7	— 46.4	— 53.7
γ Cassiopeia....	3	Dec. 7, + 6.9	— 22.4	— 21.1
β Andomedae...	2	Oct. 18, — 0.8	+ 43.8	+ 44.9
δ Cassiopeia....	2	Dec. 7, + 6.5	+ 10.4	+ 12.6
α Trianguli	2	Nov. 19, + 6.9	+ 55.6	+ 58.1
α Arietis	3	" 19, + 6.9	— 9.9	— 10.1
α Ceti	3	" 28, + 7.6	— 15.4	— 13.2
ρ Persei........	3	" 22, + 2.3	— 37.9	— 48.4
ζ Persei.......	2	Oct. 18, — 10.6	— 14.9	— 11.4
ε Tauri........	2	Nov. 22, — 1.9	+ 20.4	+ 27.5
Aldebaran ...	2	Oct. 18, + 12.4	+ 32.4	+ 27.8
Capella......	4	Apr. 17, + 14.9	+ 32.4	+ 33.1
Rigel	3	Dec. 7, + 0.3	+ 12.5	+ 12.4
γ Orionis.......	3	Dec. 3, — 2.2	+ 12.8	+ 7.4
β Tauri........	3	" 2, — 2.9	— 15.6	— 13.4
α Orionis......	2	Nov. 28, — 6.3	+ 40.1	+ 41.6
β Aurigae......	2	Apr. 9, + 15.8	— 5.3	— 3.3
Sirius........	2	Dec. 7, — 6.4	— 21.7	— 20.9
		1882.		
γ Pegasi........	2	Nov. 9, + 11.8	— 41.1	— 39.6
β Persei........	2	" 9, — 2.3	+ 18.1	— 17.3
Capella.......	2	" 9, — 9.3	+ 22.5	+ 22.6
Sirius........	6	Apr. 8, + 14.0	+ 8.2	+ 8.9
Castor	4	Feb. 10, + 10.3	+ 19.9	+ 15.3
Procyon......	4	Mar. 14, + 15.5	+ 3.2	+ 9.3
Pollux.......	4	Feb. 10, + 9.3	— 40.3	— 43.6
Arcturus.....	2	Aug. 8, + 14.1	— 54.8	— 69.1
α Lyrae........	4	Nov. 8, + 7.5	— 53.2	— 46.4
α Pegasi	2	Aug. 2, — 11.1	— 8.9	— 9.8
Moon........	5	" 2, —	— 3.0	—
Sky Spectrum.		Mar. 14, —	+ 2.7	—

In 1881 about 100 stars had been spectroscopically examined in reference to their motion in line of sight. In 1882 the same work has been continued. The examples given above will indicate what can be done very usefully in this way, and give some general idea of the methods.—ED.]

ON THE FORMATION OF THE TAILS OF COMETS.*

MR. C. A. RANYARD.

I was glad to see Mr. Green's letter with respect to the repulsive force acting on the matter of comets' tails in your February number.† By a curious coincidence, a letter making a very similar suggestion appeared in *Knowledge*, of February 1. Both Mr. Green and the writer in *Knowledge* (Mr. Grinsted) assume that space is filled with an atmosphere as attenuated as that within the bulb of Crookes' radiometer. But it is not necessary to make such an assumption in order to conceive of a repulsive force due to the action of heat. Indeed, if there were such a universal atmosphere it would offer considerable resistance to the very rapid motion of small particles which it is necessary to assume in order to account for the growth of tail occasionally observed in great comets that have passed near the sun. At a meeting of the Astronomical Society, in 1874. I suggested (see *Astronomical Register* XII, p. 80) that the accumulated effect of the minute recoils which must accompany evaporation, as molecules are thrown off from the surface of a small heated body towards the sun, would serve to account for a repulsive force sufficiently great to overcome the action of gravity and drive the small body away from the sun with great velocity.

If one half of the mass of a particle is thrown off by evaporation towards the sun with an average velocity V, the remaining half, not yet driven into vapor, will have received a series of impulses, all acting in directions nearly opposite to the source of heat, which will give a velocity

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*Communicated by the Author.

†Astronomical Register.

comparable with V, away from the sun to the remaining unevaporated half of the particle, and as the evaporation continues the velocity of the unevaporated residue will increase until it may become much greater than the average velocity with which the gaseous molecules are driven off from the heated body.

It is evident that evaporation will take place most rapidly where the sun's rays strike vertically, and if we suppose evaporation to take place so that the particles all fly off in directions which are inclined less than 45° to the line passing through the sun's centre, the resultant effect of all the recoils would give the unevaporated half of the particle a velocity greater than $\frac{V}{1.42}$ in a direction from the sun.

The velocity with which an evaporating molecule leaves the evaporating surface must at least be equal to the velocity of the free molecule in the gaseous state immediately after the evaporation. We know that the average velocity of hydrogen molecules at a temperature t is $1{\cdot}06\sqrt{\frac{t}{273}}$ miles per second, where t is the number of degrees centigrade, measured from the absolute zero of temperature, and consequently it is not necessary to assume a temperature higher than the temperature of an English summer day to give a velocity of 1·1 miles per second for the molecules of hydrogen gas, which is equivalent to a velocity of about a hundred thousand miles per day.

Hitherto we have only considered the motion due to evaporation of a part of the mass of the moving particle, but in the case of a gaseous mixture, where one element is precipitated by cold while the rest remain in a gaseous form, we may have condensation going on, on the shaded side of the precipitated particles, and evaporation on the illuminated side, while the condensed matter continually flows round to the illuminated side, or the precipitated particles may be turned by the forces acting on their illuminated surfaces.

Prof. ARTHUR WRIGHT, of Yale, has shown that when stony meteorites are heated to a temperature of only 100°C.,

a mixture of several gases—carbonic dioxide, carbonic oxide, hydrogen, &c.—is given off. In such a mixture, at ordinary atmospheric pressure, the carbonic acid would be condensed into the liquid form at a temperature of about $-80°$ C., and in a vacuum the condensation would take place at a still lower temperature. We can therefore conceive of the action described going on at very low temperatures, and can understand the formation of comets' tails at distances from the sun considerably greater than the earth's distance.

An evaporating particle near to the comet's nucleus would be acted upon by four forces, viz: gravitation towards the nucleus, and heat repulsion from the nucleus; gravitation towards the sun, and heat repulsion from the sun. If the repulsive action is in each case greater than the attractive action, the particle will be driven towards a hyperbolic surface, which has the comet's nucleus in one focus and the sun's centre in the other focus.

This is evident, for on such a hyperbolic surface the tangent T P bisects the angle S P N. If the forces in the direction S P and N P are equal, the resultant will bisect the angle between them, and the particle will be driven along in the hyperbolic surface, while if the force in the direction N P is greater than the force in the direction S P, the particle will be driven outwards till it reaches a confocal hyperbolic sheet, where the forces acting from the sun and nucleus are equal.

Particles of different sizes would be acted upon by gravitating forces corresponding to their masses, that is by attractive forces varying with the cube of the diameter of the particle, while the repulsive forces would vary with the surfaces exposed to radiation, or as the square of the diame-

ter of the particle, consequently particles of different sizes as well as substances evaporating at different temperatures, would be driven towards different hyperbolic sheets, which as seen in projection would appear as hyperbolic envelopes one within the other. Such differances in the repulsive forces would cause the matter of the different envelopes to be driven backwards into space with different velocities, and, as has frequently been suggested,* differences in the rate with which the matter of the tail is repelled would give rise to differences of curvature of different parts of the tail in the plane of the comet's orbit.

Probably all the phenomena of cometary structure cannot be accounted for on the above supposition; but I wish to point out that it is not necessary to call in a hypothetical electrical repulsive force in order to account for the chief features of cometary structure.

Bredichin, Norton, and Zollner have suggested that electricity may be generated as physical changes take place during the heating of the nucleus; and though I cannot accept their electrical theories with regard to the formation of comets' tails, I would suggest that it is possible that the bright line spectrum in the neighborhood of the nucleus may be due to a rapid succession of electrical discharges, while the general temperature of the gas remains far below the temperature of incandescence.

If the earth had no atmosphere, a particle driven upwards from the earth's surface with a velocity of a mile a second would, under the action of terrestrial gravity, only rise to a height of 82 miles, and then fall again towards the earth; but a particle driven away from a nucleus weighing

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* Matter driven backwards into space with very great velocity compared with the velocity of the nucleus in its orbit, would form a nearly straight tail in the prolongation of the radius vector; while matter driven backward with a velocity comparable with the velocity of the nucleus would drop behind the radius vector, and form a tail curving backwards in the plane of the orbit, the curvature being more and more apparent the slower the velocity with which the matter of the tail was driven away. Bond in his great Memoir on the comet of 1858, quotes observations which seem to show that the tail of that comet did not lie wholly in the plane of its orbit.

only a few pounds, or even a few million tons, with a velocity of a mile a second, would be driven off into space. It is evident, therefore, that with temperatures such as we have been supposing there would not be an atmosphere about a flight of metoric stones similar to the earth's atmosphere, but the evaporated molecules would stream away with approximately parallel motions, and a precipitated particle in the neighborhood of the heated side of the nucleus would be bombarded with molecules of evaporating gases moving in long free paths. This condition Mr. Cookes has termed "the fourth state of matter," and he has, in a series of beautiful experiments, shown that such a bombardment may be caused in a vacuum tube about a negative pole when a discharge from an induction coil is passing through the exhausted tube, and that bodies struck by particles of such radiant matter shine with a phosphorescent light, which I conceive may be the cause of the intense brightness of the suspended matter in the neighborhood of the nucleus, while the gaseous molecules during their long free paths would give out their own distinguishing wave lengths. Thus, without electrical discharges, the whole phenomenon of the continuous and bright line spectrum in the neighborhood of the nucleus may be accounted for.

The few observations I have collected with regard to the polarization of the light derived from the tails of comets show that there is usually but little polarization in the neighborhood of the nucleus, but in the tail the polarization is more or less intense according to the position of the comet with respect to the earth and sun.

If the line joining the earth and comet makes a small angle with the direction in which the sun's light falls upon the comet, the polarization is small, but the intensity of the polarization increases as the angle between the line joining the earth and comet and the direction of illumination increases towards a right angle. This seems to indicate that the polarization is due to the dispersion of the sun's light by particles whose diameters are small compared with the wave length of light.

Great Comet of 1882, from a drawing by Dr. Temple, of Arcetri, 18th October, 16th.*

The phenomena exhibited by the recent brilliant comet seem to afford evidence of matter streaming away from the brighter parts of the tail towards the sun. Mr. Gill's photographs, as well as the drawings by Schmidt, Temple, and others who observed in a clear atmosphere, show a broad band of faint light, which is traceable backwards from the bright parts of the tail, far beyond the nucleus, in the direction of the sun. The band evidently does not spring from the nucleus, as it is not symmetrically placed with respect to it, but it corresponds with the broader and brighter parts of the tail. It was very faint, as compared with the brighter parts of the tail, and does not seem to have been observed in England, but considering the number of observers who saw it with clearer skies there can be no doubt as to its existence. Such a sunward pointing tail may be a phenomenon attending all comets, but owing to the extremely divided state of the sunward streaming matter, the tail towards the sun may always be much less noticeable than the tail directed away from the sun.

Fan-shaped forms, composed of intersecting arcs in front of the nucleus, have been frequently observed, which may

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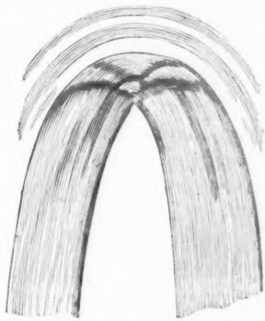
* The plane of the comet's orbit was inclined at an angle of about 38° to the ecliptic. The earth passed through the plane of the comet's orbit about the end of the first week in September, so that at the date of the drawing a straight tail directed away from the sun with a series of broader tails curving backward with different curvatures in the plane of the orbit would be seen from the earth as merged together near the nucleus, an but slightly separated from one another, where the actual separation in the plane of the orbit was greatest. Dr. Temple's drawing seems to be consistent with ths assumption that the comet had four distinct tails, viz., a narrow straight, or nearly straight tail, directed away from the sun, two broader tails, curving backwards with different curvatures in the plane of the comet's orbit, and a much fainter broad straight tail with parellel edges, directed towards the sun.

be accounted for by supposing that hyperbolic envelopes about different nuclei are occasionally seen in projection, one through another. Take, for example, the drawings of Coggia's comet, as seen by Rayet, or the drawing of the same comet by Mrs. Newall, which is given in the *Monthly Notices* for March, 1876.



Coggia's Comet, as observed by Mrs. Newall, August 12, 1874.

Frequently the nebulous matter is pretty uniformly distributed within the head of the comet. Such a structureless appearance may be accounted for by supposing that the precipitated mist which forms about the nucleus is made up of minute drops of different sizes, or of small solid particles, crystalline or otherwise, not uniform in size, which are driven to different distances from the nucleus. A widely distributed swarm of meteors with envelopes about each of them might also give rise to such a structureless tail. Comets with a large nebulous head and a much narrower tail, like comet II. of 1868, or the great comet of 1861, when it was first seen, may be due to a widely-distributed swarm of meteors with a much-condensed nucleus, the broad and faint tail from the outlying members of the swarm being too faint to be seen through the veil of our atmosphere.

The drawings of the same comet by different observers differ very considerably, but there seems to be undoubted evidence that jets not in the direction of the radius vector are occasionally projected from the nucleus, and that the

matter of the tail is not uniformly thrown backwards in all directions around the nucleus. As the earth passed through the tail of the great comet of 1861, long faint rays were observed all pointing away from the nucleus—showing that the matter of the tail was streaming away more thickly in some directions than in others.

NEW STAR CATALOGUE.

PROF. T. H. SAFFORD.

I send enclosed a trifling installment of a star catalogue which I have in progress. The observations were made during the last four months of 1882, with the Repsold Meridian Circle of the observatory; an instrument whose telescope has an aperture of 4½ inches (French,) and whose divided circle is 20 inches in diameter. Observations of declinations of these and other stars will follow in proper time. The working list comprises the stars to the magnitude 7.4 inclusive from the Durchmusterung within 10° of the pole, and such other stars as have been or are used as standard polars, and certain stars within 10° of the pole which exhibit signs of proper motion.

In selecting the present list for publication, I have taken no stars whose apparent or mean places are now given in the Jahrbuch, and only such other stars as have been at least four times observed. The polars of the Jahrbuch have been much observed; but their complete reduction will be made only after the meridian mark is set up. No observation of any star has been rejected: three or four doubtful ones have received half weight.

The collimation was determined by combination of nadir and level readings; the value of Bessel's n and the clock correction from standard stars of the "Mittlere Oerter." Especial pains has been taken to equalize the number of Standard polars above and below pole.

All the transit observations have been taken and reduced by myself; the collimation has been determined by Messes. Frederic J. Parsons and John Tatlock jr. students in astronomy.

All the observations were made in the position W. I of the instrument. The probable error of one observation is $\pm$ $0^s.0264$ sec δ. The star Gr. 1119 (Decl. $88^\circ.98$) for which a daily ephemeris is given in the Connaissance des Temps, requires a correction in that work of nearly 7^s of time; a single Montsouris observation confirms this correction.

MEAN RIGHT ASCENSIONS FOR 1882.0 OF 24 STARS NEAR THE NORTH POLE.

From observations at the Field Memorial Observatory of Williams-College, Williamstown, Mass.

Name of Star.	Obs.	AR. 1882.0	Ann. Prec.	Sec.Var.	App. Decl.
		h m s	s	s	° ′
Camelop. 25 H.....	5	7 6 10.21	+ 12.9874	− 0.4961	82 38.0
Gr. 1119*).	4	7 37 33.75	+ 71.3669	−31.483	88 58.7
Gr. 1359...........	4	7 48 30.67	+ 15.1946	− 1.2421	84 23.6
Gr. 1418......... ...	4	8 20 22.08	+ 16.8708	− 2.1719	85 28.0
Schwerd 529........	4	8 38 20.02	+ 11.6653	− 1.0546	83 9.8
Schwerd 533.... ...	4	8 41 4.10	+ 11.6178	− 1.0693	83 11-6
Radcl. C. 2218... ..	5	8 50 30.33	+ 13·5792	− 1.7028	84 39.1
Radcl. C. 2594......	4	11 0 3.90	+ 14.5869	− 8.1721	88 16.8
Gr. 1782............	4	11 23 27.87	+ 4.5409	− 0.3998	81 46.6
Gr. 3212	5	20 16 26 36	− 8.0600	− 1.0516	84 19.3
Schwerd 1213.......	5	20 21 7.42	− 3.2204	− 0.3094	80 9.7
Br. 2673	4	20 30 30.45	− 0.2121	− 0.0672	72 7.9
Br. 2701*)...........	4	20 34 13.30	− 3 5526	− 0.3923	81 1.9
75 Draconis	4	20 35 35.00	− 3.5104	− 0.3912	81 1.1
74 Draconis.........	4	20 36 13.84	− 3.2515	− 0.3589	80 40.6
BC. 4976...........	4	20 40 45.26	− 5.5113	− 0.7439	83 12.9
BC. 5228...........	4	21 18 11.76	− 2.2449	− 0.3451	80 44.1
Gr. 3548*)	4	21 22 56.92	− 10.9474	− 3.1126	86 32.8
Pi. XXII. 280......	4	22 50 20.68	− 0.8351	− 0.4296	84 9.2
Cephei 36 H........	4	22 55 17.97	− 0.3090	− 0.3129	83 42.9
o Cephei...........	4	23 13 47.08	+ 2.4270	+ 0.0407	67 27.9
Cephei 39 H.*)......	4	23 27 49.87	− 0.1290	− 0.5471	86 39.4
Gr. 4163............	4	23 49 6.08	+ 2.8543	+ 0.0894	73 45.2
Br. 3194............	4	23 53 58.66	+ 2.5637	+ 0.2911	86 3.0

*) These four stars are reduced to mean place by the help of the Connaissance des Temps or the Montsouris ephmeris, and slight corrections have yet to be applied.

Williamstown, Mass. 1883. *A. N. No. 2496.*

Catalogue des Etoiles Doubles et Multiples en mouvement relatif certain, comprenant toutes les observations faites sur chaxue couple depuis sa decouverte et les resultats conclus de l'etude des mouvements. PAR M. CAMILLE FLAMMARION. Grand in-8; 1878. —Prix : 8 francs.

EDITORIAL NOTES.

H. C. Wilson, acting director of the observatory at Cincinnati, and wife, visited his home in Minnesota, and were present at the funeral of his mother, the sad event occurring April 7.

The new dome for the great equatorial of the Leander McCormich observatory of the University of Virginia, is being constructed by Messrs. WARNER & SWASEY, of Cleveland, O. Quite recently Professor STONE, the director, gave the work personal inspection, and he reports that it is progressing finely.

Amateur observers who desire to undertake regular work in observing variable stars according to the excellent plan devised by Professor PICKERING should have a good star atlas. PROCTOR'S Atlas will serve the purpose well, but the *Atlas Coelestis Novcs*, by HEIS, is perhaps the most convenient work of the kind. Copies can be procured through B. WESTERMANN & Co., New York city. The cost for an institution of learning allowed to import free of duty will be $6.44; with the duty about $8.80.

The expedition to observe the total eclipse of the *Sun* May 6, 1883-with Professor E. S. HOLDEN, in command, arrived in Callao, Peru, safely. March 24, the party sailed from this point, in the U. S. Steamer Hartford, for the Caroline Island, the point of destination for observation. The party will remain on the island about three weeks, and will return home by the way of the Sandwich Islands and San Francisco, arriving at the latter place about the middle of June. Earliest news from the expedition is expected from San Francisco.

The work to be done by members of the solar eclipse party, so far as known, is as follows: Professor HOLDEN, chief of the party, is to look for intermercurial planets during totality; astronomical work at other times. He has a six-inch Clark equatorial. Mr. C. H. ROCKWELL will observe with the 4.1-inch equatorial with grating spectroscope attached. Mr. BROWN, of the U. S N. Obs. will assist Mr. PRESTON, of the Coast Survey, who goes primarily to determine the force of gravity by observations with the pendulum. Mr. W. UPTON of Signal Service during the eclipse, will make either spectroscopic or photometric observations; at other times do meteorological work. Professor HASTINGS, of Baltimore, will give his attention to the spectroscope, chiefly using with it a 6¼-inch equatorial. The arrangements made for observations with the polariscope and other instruments in the possess- of the party are unknown to us.

OCCULTATION OF β^1 AND β^2 SCORPII, 1883, MARCH 1ST, A. M., CIVIL TIME.

I formed a tremendous resolution to get up in time to see the occultation, and by the aid of an alarm clock succeeded in doing so. The following are the recorded Baltimore mean times:

Immersion.					*Emersion.*				
β^1	Bright limb	4^h	16^m	35^s	β^1	Dark limb	5^h	16^m	5^s
β^2	" "	4	17	15	β^2	" "	5	16	49

Immersion. Sky clear, but small circle around moon. Definition not very good, stars trembling, but limb of moon appeared very steady and clear cut. A minute or two before the predicted time, I took the second from chronometer and counted along with my eye at telescope. β^1 came up to limb first and disappeared at time noted above. In 40^s the companion came up. The times noted are when the stars were positively seen for the last time.

Emersion. Sky still clear and circle about moon gone. Definition somewhat better, temperature inside and outside more equable. Dark limb of the moon plainly visible through telescope. Taking the second from chronometer as before, I awaited the re-appearance. β^1 flashed out suddenly at the position I was watching. Immediately wrote down the second, turned to the chronometer and noted the minute, and then taking the correct second, counted for the companion. In precisely 44^s β^2 came out. The re-appearance of both stars was certainly sudden, though not what I would call instantaneous. For a small portion of a second β^1 seemed to have caught on the limb, and then instantly with a rebound, as it were, stood out clear upon the sky. The phenomenon of re-appearance was a very beautiful one.

Telescope 4-inch equatorial by Cooke of York, England, power used 60, chronometer by NEGUS, error being known by comparisons with W. N. Signal, Feb. 28 and Mar. 1. Longitude 1^m 45^s E. of Washington.

W. H. N.

An optician interested in object-glasses of short focal length, says "An O. G. made of Chance's glass has the prismatic angle for the

Crown disc	8°	20′
Flint disc	4	14½
Surplus angle	4	5½

The focal leught is 1 to 17.

In the case of focal length which is as 1 to 9, the O. G.

Crown disc	15°	44′
Flint disc	8	25
Surplus angle	7°	19′

This is undesirable. Unles the glasses are equal in dispersion, the irrational spectrum is so dominant as to be worse than spurius discs."

MINOR PLANETS.

Eleven minor planets were discovered in 1882, and one up to the present date in 1883, as follows:

No.	Name of Planet.	Date of Discovery, 1882.	Discoverer.	Place of Discovery.
(221)		Jan. 18,	J. Palisa,	Vienna.
(222)		Feb 9,	"	"
(223)		Mar. 9,	"	"
(224)		Mar. 30,	"	"
(225)		Apr. 19,	"	"
(226)		July 19,	"	"
(227)	Philosophia,	Aug, 12,	Paul Henry,	Paris.
(228)		Aug 19,	J. Palisa,	Vienna.
(229)		Aug. 22,	"	"
(230)	Athamantis,	Sept. 3,	De Ball,	Bothkamp.
(231)		Sept. 10,	J. Palisa,	Vienna.
		1883.		
(232)			J. Palisa,	Vienna.

J. Palisa, the discoverer of ten minor planets following (220) by number, has not yet named any of the list so far as known. The supplement of the *Berliner Jahrbuch* is authority for the calculated ephemerides of the minor planets for the year of 1883, giving the times and places of forty-three of the group near opposition, for midnight Berlin time. The minor planets which approach nearest the *Earth*, in 1883 are *Isis*, *Phocea*, *Clio*, *Flora*. *Virginia*, *Polyhymuia*, *Fortuna*, *Metis*, and *Juno*. *Isis'* nearest approach to the *Earth* will be 0.895; *Juno's* 0.180, the radius of the *Earth's* orbit being unity.

Professor T. H. SAFFORD, director of the Field Memorial Observatory of Williams College, Mass., is now engaged on a catalogue of northern circumpolar stars, a most important piece of astronomical work, which he is carrying forward as fast as other duties will permit. His working list contains stars down to the 7.4 magnitude, iuclusive, within 10° of the pole, which show signs of proper motion. The mean right ascensions of the stars will first be determined and afterward their declinations in proper time. Few, who are unacquainted with the work of measuring the right ascensions of stars near the pole, know the difficulty of it. On this account as much as on any other, it has been neglected or avoided in the past. We are extremely glad that Professor SAFFORD has uudertaken the work, and this catalogue is deemed so necessary to every working observatory that we have sought the privilege of publishing it, in small installments as the work goes on, with the idea of getting it into the hands of observers as early as possible. Extra copies of the MESSENGER containing this work can be had by any wanting them.

As astronomers furnish the standards of time for the world, none can be more interested than they, in the discussion of radical changes in the standards now in use. At a convention of railroad managers, held in St. Louis April 11, at which were present seventy-five delegates from various railroads of the United States, the following resolutions were passed unanimously, recommending four standards of time for the Conttennt as follows:

Resolved that the convention recommend the following to be the future standard of time:

First—That all roads now using Boston, New York, Philadelphia, Baltimore, Toronto, Hamilton or Washington time as standards east of those points or adjacent thereto, shall be governed by the 75th meridian, or Eastern time.

Second—That all roads using Columbus, Cincinnati, Louisville, Indianapolis, Chicago, St. Louis, Atlanta, Jefferson City, St. Paul or Kansas City time, or standard time adjacent thereto, shall be run by the 90th meridian time, or one hour slower than Eastern time, to be called Central time.

Third—That west of the above named sections all roads shall be run by the 105 and the 120th meridian times, which are respectively two and three hours slower than Eastern time.

Fourth—That all changes shall be made at the termini of roads or at the ends of divisions.

Fifth—That the secretary be instructed to forward a copy of these resolutions to all general managers and representatives, with a request for a response, whether they are in favor or not of the plan proposed, and whether they will or not adopt the proposed standard, and that a copy of the report and of the maps submitted to this convention accompany this report. That the secretary be instructed to endeavor to meet any objection that may be received, and that the replies be embodied in a report to the next convention.

Our many friends among observers will please bear in mind, that ordinary matter, by mail, intended for any particular issue of the MESSENGER should be on hand on or before the 20th of the preceding month. Important astronomical news, however, may be telegraphed, at our expense, as late as the 25th of each month of publication. By courtesy of the Western Union Telegraph company, recently extended to the MESSENGER, this ready and helpful means of gathering news from all parts of the United States is kindly placed in our hands that our readers may have the latest promptly distributed. We are sure, that every lover of astronomy will join us in heartily commending the generous and intelligent patronage of our science, by the officers of the Western Union company which, is often evinced in such acts as these.

Celestial photography is certainly and rapidly coming to important uses in practical astronomy. At the meeting of the Royal Astronomical society in March, Dr. B. A. GOULD, director of the National observatory at Cordoba, South America, gave an account of his own work in the line of stellar photography. In the course of examinations of the Southern heavens, he has selected forty or fifty star clusters which seemed to give great promise, and of these he has taken a number of photographs on a small scale, which he proposes to measure by the aid of one of Mr. Rutherford's excellent micrometers. Some of these pictures have been enlarged so as to insert the names of the stars. "One is *Kappa Crucis*, a beautiful cluster supposed to present all the colors in the rainbow; a second *x Corinae*; two others are nebulae in *Scorpio*, six and seven Messier." These photographs show stars down to magnitudes 10½ or 11, the chief trouble being to get clock-work steady enough to secure the motion of the telescope so exactly uniform during the long exposures, that the star-dots shall be round and without trails.

Dr. GOULD has also secured photographs of *Zetra Hydi*, *Epsilon Indi*, and the very notable star *Beta Hydri*.

The principal thing, however, that now claims the attention of the corps of observers at Cordoba is the revision of the zone catalogue of 1875. Some 30,000 stars in it have their places determined by single observations. These are being reobserved in duplicate, and carefully compared. The entire revision which includes other important points as going on had recently reached the 8th hour, the copy up to the 6th hour being in the hands of the printer. In less than one year it is hoped that the zone catalogue, in two volumes with 74,600 stars, will be published and ready for distribution.

Dr. GOULD also has, under way, another important catalogue to contain about 34,000 stars, inclusive down to the 8th magnitude, which covers every part of the southern hemisphere, while the zones extend from the tropic only to within 10° of the South Pole. The stars of the smaller catalogue are more carefully observed, and the chances are that if an 8th magnitude star is needed for auy purpose that it will be found in this catalogue.

There seems to be a remarkable uncertainty respecting the outcome of the present official management of the observatory at Cincinnati, if we judge rightly of the recent action of the Board of Directors concerning the position of astronomer. At the February meeting, a report of the work and condition of the observatory was made, and it was voted to invite applications for the position of astronomer at a salary of $3,000 a year. This motion was reconsidered later, and now the observatory committee are asked to make a report showing what instruments are needed to complete the equipment with their probable cost.

The acting astronomer, Mr. Wilson is practically alone with all the routine work of the observatory on him, and, so far as we can learn, has no definite knowledge of future plans for its management. This state of things is strangely in contrast with the high character, this grand old observatory has maintained in this country and the world from the time of its projector and first director, the distinguished O. M. Mitchel.

Comet *a*, 1883, has dimished in brightness so rapidly as to be already quite out of sight. The only interesting fact in its appearance not already spoken of, is, that some observers have noticed a granular appearance in the structure of the nucleus, like that of a resolvable nebula.

BROOK'S Telescopic Comet, 1883.

The accompaying sketch, made and kindly sent us at the time of discovery by Professor W. R. BROOKS, would have appeared last month, but for a curious mistake on the part of our engraver. The following elements as given in the *Observatory* were obtained by Dr. H. OPPENHEIM, from observations, 1883, February 24, at Cambridge, Mass.; March 2, at Hamburg and Kiel, and March 8, at Kiel, parallax and abberration being taken into account.

ELEMENTS.

Perihelion passage = 1883, February 19.1234 Berlin M. T.

Long. (Per. Node)	110°	10′	42″
Long. Per.	278	14	29
Inclination	78	2	8
Log. y	9.88086		

The middle place is represented in longitude and latitude, by + 11″ and + 20″ respectively.

The degree of L L. D. has been conferred on Maria Mitchell, director of the observatory at Vassar college.

It seems, by late news, that the French Scientific Expedition was expecting to meet, at Panama, a French naval vessel that would transport them to Caroline Island. While observing the eclipse this party intend to search for small planets near the sun, by the aid of photography. In the hands of M. JANSSEN, the distinguished artist in solar photography, astronomers may hope for the best possible results in this new trial of the uses of photography. After the eclipse the party will go to Takiti, and M. JANSSEN will then visit the observatories and other scientific interests in different parts of the United States.

The rain-band spectroscope is coming into favor in the United States to some extent. Mr. W. UPTON of Signal Service, presented an instructive paper on this new mode of observation. C. PIAZZI SMYTH, Astronomer-Royal of Scotland has recently published full observations made by this instrnment. Messrs Jas. W. QUEEN & Co. of Philadelphia, have just made an inportation of these spectroscopes, which are of the same pattern as that used by Mr. J. RAND CAPRON of England.

The regular observations of the *Sun* at Carleton college observatory have been much interrupted during the last month by cloudy weather. The sun-spots seen were usually small, and the faculae generally neither bright nor considerable. On the 3d, 28 spots were counted, and on 23d, 40. Near the middle of the month one sun-spot was large enough to be seen by the naked eye. W. E. C.

Professor T. A. SMITH, new observatory at Beloit college has done some work on the constants of his instruments. The new spectroscope is yet in the hands of the makers, Messrs Fauth & Co., Washington, D. C. It is to be constructed to use either a prism or diffraction grating.

Some time ago we noticed this extract from Report of Prof. E. C. PICKERING of Harvard college observatory, Nov. 1878: "The error of the Standard Clock, Wm. Bond & Son, No. 394 which sends the time signals, has exceeded .7^s on twodays only during the year. Since July 1, it has exceeded .1^s on nine days only.

Our friend, C. E. CRANE, auditor of Waseca county, Minn. spends leisure hours in the study of astronomy. He is now having a 6½-inch clear aperture reflecting telescope made by Mr. BRASHEAR of Pittsburg.

Mr. W. UPTON, member of the solar eclipse party has written an interesting letter from Callao, Peru, dated March 22.

We have given considerable space, in preceding numbers, to an exhaustive paper written by Professor NEWCOMB on the present state of astronomical science and the work which ought to be done. That paper, as we have before said, is the Introduction to a volume of astronomical papers prepared for the use of the American Ephemeris. The volume consists of six parts, as follows:

1. On the recurrence of solar eclipses with tables of eclipses from B. C. 700 to A. D. 2300, by Simon Newcomb.
2. A transformation of HANSEN'S Lunar theory compared with the theory of DELAUNAY, by Simon Newcomb aided by JOHN MEIER.
3. Experimental determination of the velocity of light, made at the United States Academy, Annapolis, by ALBERT A. MICHAELSON.
4. Catalogue of 1098 standard clock and zodiacal stars, prepared under the direction of SIMON NEWCOMB.
5. On Gauss' method of computing secular purturbations, with an application to the action of *Venus* and *Mercury*, by GEORGE W. HILL.
6. Discussion of observed transits of *Mercury*, 1677-1881, by SIMON NEWCOMB.

The MESSENGER is not forgetful of the many encouraging and complimentary notices which the home and foreign papers have so generly given it; neither is its editor unmindful of those genial private letters kindly written him by such distinguished foreign gentlemen as C. PIAZZI SMYTH, Astronomer-Royal of Scotland; E. W. MAUNDER, F. R. A. S., editor of *The Observatory*, Greenwich, Eng.; W. TEMPLE, director of the Astronomical observatory, in Arcetri, Italy; Dr. J. L. E. DREYER, editor of *Copeimcus*, Armaugh, Ireland, and others that equally deserve special mention. These, with all the large circle of home friends, too many to be named, and yet too kind to be forgotten, have, every one, rendered generous and helpful assistance in the beginning of our new and doubtful enterprise.

Astronomsche Nachrichten, No. 2501 contains articles and letters from several different American astronomers. Professor SAFFORD fills two pages with a descriptive "Comparison of *Albricht's* Catalogue of Polar stars with the Harvard Catologue (Safford) of 1865." The general agreement is remarkable. Professor HASTINGS, of Baltimore, writes "On the variation in the focal length of an objective with change of temperature." Prof. H. C. WILSON, of Cincinnati communicates observations of the Great Comet of 1882, and Prof. SWIFT, of Rochester, a note on the late comet.

Mr. JOHN R. HOOPER, followed the Great Comet until March 24, with considerable ease, March 27, it was so faint that it was only seen by gently moving the glass. It has not been observed since.

THE PLANETS FOR MAY.

1883, May 1. *Sun* fast on mean time, the equation of time being 3^m $0^s.26$; May 15, 3^m $50.^s29$; May 31, 2^m $28^s.99$.

The Sidereal time of Greenwich mean noon, May 15, 3^h 31^m $29^s.20$. The logarithm of the radius vector of the *Earth* changes from 0.0035077 on May 1, to 0.0062027 May 31.

Mercury is an evening star and will be about one hour east of the *Sun*. May 1, he will be in conjunction with *Saturn*, being 3° 54′ north. His declination then being 21° 26′ north makes his position favorable for observation which will continue for a considerable part of the month. On the 13th he will be in greatest eastern elongation, and on the 26th will be stationary.

Venus is still a morning star about two hours west of the *Sun*, and will reach the aphelion of her orbit, May 1, semidiameter then being 7″. The greatest angular semi-diameter was Jan. 1, 24.″4, the least will be in August, 5″. May 3, 19^h, is in conjuction with the *Moon* being 4° 52′ south.

Mars is west of the *Sun* and too near for any observation of special interest. He will be in conjunction with the *Moon* May 3 22^h, being 3° 58′ south.

Jupiter is easily recognized as the brightest early evening star. The observations of his belts, even in small telescopes, have recently been interesting. Their colors have attracted the attention of amateur observers.

May 2, 9^h 9^m, Washington M. T. the 3d satellite will begin its transit across the planet's disc; May 6, 8^h 30^m 47.9^s, 1st satellite eclipsed; 7th, 7^h 50^m, 4th satellite in occultation; at 8^h 40^m 2nd, transit of shadow; at 9^h 33^m 4th reappears; at 9^h 36^m shows egress of transit. May 16, 8^h 17^m $29.^s5$, 2nd satellite reappears from eclipse. May 20, 8^h 10^m $5.^s7$, 3d satellite disappears in eclipse. For Northfield meridian, subtract 1^h 4^m $23.^s8$.

Saturn is an evening planet nearing the *Sun*, and in conjunction with the *Moon* May 7th, and will pass behind the *Sun* May 20.

Uranus is 11^h 22^m right ascension, and is in conjunction with the *Moon*, May 15. 14^h being 5° 16′ north.

Neptune will be in conjunction with the *Moon*, May 6; with the *Sun* May 8. The eclipse of the *Sun* May 6 is invisible here.

The bright star *Spica* in *Virgo* will be occulted by the *Moon* May 18, 4^h $46^m.7$, Washington M. T. Observers in the East may see it as it occurrs a little after the rising of the *Moon*.

BOOKS.

Graphic Algebra or Geometrical Interpretation of the Theory of Equations of one unknown quanity by A. W. Phillips and W. Beebe, assistant professors of mathematics in Yale college, New York. Henry Holt & Co., publishers, 1882, p.p. 156.

Of late years, more and more graphical methods have come into use in the different departments of science. The method in pure mathematics is always convenient, and often a necessity to enable the mind to get a clear and comprehensive view of analytical expressions or processes. In applied mathematics, the simplicity, elegance and directness of it have won for it universal favor, and we see, in political economy, history and social science, as well as in physics, meteorology and practical astronomy, the varied use it may serve. Further, it is a constant wonder that more use is not made of this method by those who instruct in the theories of equations, in colleges and academies. That which, as usuually taught, is obsure and forbidding to the averege mind, by this method becomes clear and of absorbing interest in the mastery of Sturm's theory and Horner's method. Besides the most elemental topics which are found in the best text-books of the present time, such as the following are very clearly presented:—Direcion of the curve, the derivitive curve, equal roots, interpritation of maginary roots of derivitive equations, Horner's method of approximation, four positions of the tangent, extraction of the roots of numbers, symmetry, negative roots, isometric projection, discussion of equations of the second and third degrees, graphic solution of cubics and roots of any degree.

The author has done well, a much-needed work in preparing this book. Instructors of mathemacics and all lovers of the science can but be profited in its perusal.

Madeira Meteorologic, being a paper read before the Royal Society, Edinburgh, May 1, 1882, by C. Piazzi Smyth, F. R. S. E. and Astronomer-Royal for Scotland. Edinburgh: David Douglas, Publisher, 1882, pp 83.

This paper is printed beantifully in book form, and consists of five parts, giving first of the chief features of Madeiran Meteorology now to be inquired into; next, cycle of a day and succession of days in Madeira as compared with Lisbon; then, cycle of the year, as compared with several other places in nearly similar latitude: next, occasional peculiar phenomena, and lastly the general results for animal and vegetable life. The first plate is a full page frontis-piece showing the base of the remarkable cloud of June 26, 1881; a curious rock, also, broken off from an old lava stream in the south coast of Madeira and now in deep water. Plate second represents the spectroscopic watery vapor-band, commonly called rain-band, at different seasons and places, and reveals with accompaying observations much of interest

concerning the usually invisible watery vapor desolved in the atmosphere.

This delightful paper reads as smoothly as a fairy tale, and its perusal makes the reader long anew for the pen of the ready writer.

Plane and spherical Trigonometry by G. A. Wentworth, A. M. professor of mathematics in Phillips Exeter Academy, Boston. Messrs. Ginn, Heath & Co., publishers, 1882, pp. 134. Answers and tables following.

The student in Trigonometry will find in this book all that is really taught in the best schools and colleges in the ordinary course of study. Its arrangement is convenient and logical, statement of principles concise and clear, and its problems abundant. The proofs of propositions are carefully considered, and approved methods of arranging and executing logarithanic work have been supplied. The book is commended also, as a neat specimen of the printer's art.

MAGAZINES.

L'Astronomie (French) is a monthly review of popular astronomy, of meteorology, and of physical science, by M. Camille Flammarion. The articles of the April number were: The progress of physical astronomy, Celestial photography, by M. Janssen; Whence come storms? by M. C. Flammarion; Telescopic observations of the planet Mercury by W. F. Denning; Increase of the scintellations of stars during aurora borealis, and a full table of scientific news, important parts of which are illustrated by thirteen appropriate cuts. Subscription price per year is 13 fr. Handsomely bound for 1882, 14 fr.

Popular Science Monthly, published by D. Appleton & Co., New York, is already on hand for May. This number contains two good articles for students of astronomy, viz: Lengthening the visible Spectrum, by Johannes Gotz, and the Boundaries of Astronomy. Is Gravitation Universal? by Robert S. Ball, F. R. S., besides the usual full and excellent table of contents.

The Observatory for April, concludes the account of observations of the Lunar crator Plato by Stanley Williams—has Professor E. C. Pickering's article on observatious of the variable stars— The Periodicity of Aurorae, and Maderia Spectroscopic by W. H. M. Christie, Astronomer Royal, of England. The correspondence and notes always bring late and welcome intlligence.

The Astranomical Register is notably punctual. Besides giving the proceedings in full, of the late meeting of the Royal Astronomical Society, we have selenographical notes, Father Secchi, and an interesting table of correspondence, and astronomical occurrences.

Copernicus, another most valuable visitor, has not yet made its appearance for March. When here it will doubtless pay us for waiting.

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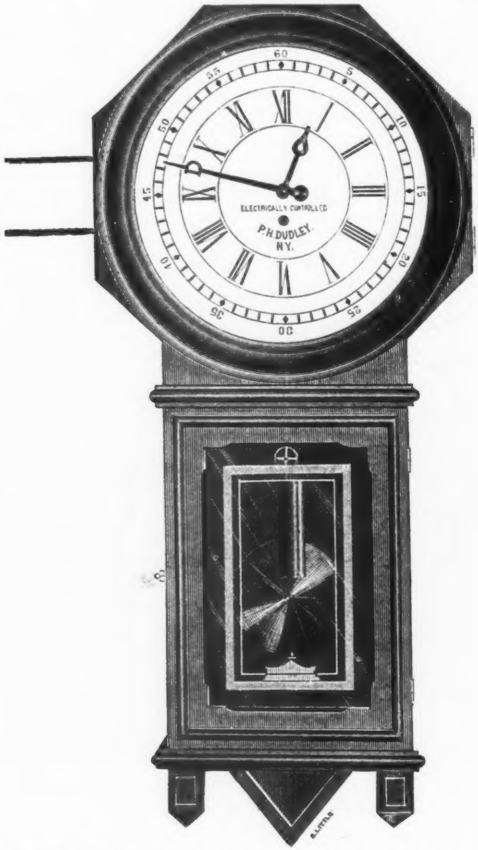

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